

CHAPTER II - RECONNAISSANCE & COMMUNICATIONS

1. GENERAL

The Joint Typhoon Warning Center relies primarily on two reconnaissance platforms, aircraft and satellites, to provide the required fix data for tropical cyclone warnings. In 1976 these two platforms provided 74.7% of the fixes used for tropical cyclone warnings in the western North Pacific. Radar, synoptic data and extrapolation were the basis for the remaining 25.3%. In the Indian Ocean area of responsibility 89% of all warnings were based on satellite data.

2. RECONNAISSANCE RESPONSIBILITY AND SCHEDULING

Aircraft weather reconnaissance is performed in the JTWC area of responsibility by the 54th Weather Reconnaissance Squadron (54 WRS). The squadron, presently equipped with six WC-130 aircraft, is located at Andersen Air Force Base, Guam. From July through October, augmentation by the 53rd Weather Reconnaissance Squadron at Keesler Air Force Base, Mississippi brings the total number of available aircraft to nine. The JTWC reconnaissance requirements are provided daily throughout the year to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC). These requirements include area(s) to be investigated, tropical cyclone(s) to be fixed, fix times, and forecast position of fix. In accordance with CINCPACINST 3140.1M, "Usage of reconnaissance assets in acquiring meteorological data from aircraft, satellites and land-based radar shall be at the discretion of FLEWEACEN/JTWC Guam based on the following priorities:

- (1) Alert flights and vortex or center fixes as required for issuance of tropical cyclone warnings in the Pacific area of responsibility;
- (2) Center or vortex fixes as required for issuance of tropical cyclone warnings in the Indian Ocean area of responsibility;
- (3) Supplementary fixes; and
- (4) Synoptic data acquisition".

As in previous years, aircraft reconnaissance provided direct measurements of height, temperature, flight level winds, sea level pressure, estimated surface winds (when observable) and numerous additional parameters. These data provide the Typhoon Duty Officer indications of changing cyclone characteristics, radius of cyclone associated winds and position and intensity determinations. Another important aspect of this data is its availability for research in tropical cyclone analysis and forecasting. Aircraft reconnaissance will become even more important in years to come when high-resolution tropical cyclone dynamic steering programs will require a dense input of wind and temperature data.

DMSP satellites and USAF ground sites provide day and night coverage of the JTWC area of responsibility. Interpretation of this satellite imagery provides cyclone positions, and for daytime passes estimates of storm intensities are also made. This year timely readouts were available at JTWC only for the 0000Z and 1200Z warnings. DMSP

satellite positions received at JTWC from the Air Force Global Weather Central, Offutt Air Force Base, Nebraska were timely for the 0800Z and 2000Z warnings in the Indian Ocean. As in 1974 and 1975, satellite metwatch of the western North Pacific proved extremely useful in identifying areas of possible tropical cyclone formation, thus reducing the number of aircraft investigative flights. The Detachment 1, 1st Weather Wing DMSP site on Guam was modified in February 1977 to receive and process data from NOAA satellites.

Land radar also provides very useful positioning data on well developed cyclones when in proximity (usually within 175 nm of the radar site) of the Republic of the Philippines, the Republic of China, Hong Kong, Japan (including the Ryukyu Islands), Korea, and Guam.

3. AIRCRAFT RECONNAISSANCE EVALUATION CRITERIA

The following criteria are used to evaluate reconnaissance support to JTWC.

a. Six-hour fixes - To be counted as made on time, a fix must satisfy the following criteria:

(1) Fix must be made not earlier than 1 hr before, nor later than 1/2 hr after scheduled fix time.

(2) Aircraft in area requested by scheduled fix time, but unable to locate center due to:

- (a) Cyclone dissipation; or
- (b) Rapid acceleration of the cyclone away from the forecast position.

(3) If penetration not possible due to geographic or other flight restrictions, aircraft radar fixes are acceptable.

b. Levied 6-hr fixes made outside the above limits are evaluated as follows:

(1) Early-fix is made within the interval from 3 hr to 1 hr prior to scheduled fix times. However, no credit will be given for early fixes made within 3 hr of the previous fix.

(2) Late-fix is made within the interval from 1/2 hr to 3 hr after scheduled fix time.

c. When 3 hr fixes are levied, they must satisfy the same time criteria discussed above in order to be classified as made on time. Three-hour fixes made that do not meet the above criteria are classified as follows:

(1) Early-fix is made within the interval from 1 1/2 hr to 1 hr prior to scheduled fix time.

(2) Late-fix is made within the interval from 1/2 hr to 1 1/2 hr after scheduled fix time.

d. Fixes not meeting the above criteria are scored as missed.

e. Levied fix time on an "as soon as possible" (ASAP) fix is considered to be:

(1) Sixteen hours plus estimated time enroute after an alert aircraft and crew are levied; or

(2) Four hours plus estimated time enroute after the DTG message levying as ASAP fix if an aircraft and crew, previously alerted, are available for duty.

f. Investigatives - to be counted as made on time, investigatives must satisfy the following criteria:

(1) The aircraft must be within 250 nm of the specified point by the scheduled time.

(2) The specified flight level and track must be flown.

(3) Reconnaissance observations are required every half-hour in accordance with AWSM 105-1. Turn and mid-point winds shall be reported on each full observation within 250 nm of the levied point.

(4) Observations are required in all quadrants unless a concentrated investigation in one or more quadrants has been specified.

(5) Aircraft must contact JTWC before leaving area of concern.

g. Investigatives not meeting the time criteria of paragraph f, will be classified as follows:

(1) Late-aircraft is within 250 nm of the specified point after the scheduled time, but prior to the scheduled time plus 2 hr.

(2) Missed-aircraft fails to be within 250 nm of the specified point by the scheduled time plus 2 hr.

4. AIRCRAFT RECONNAISSANCE SUMMARY

During the 1976 tropical cyclone season 310 six-hourly vortex fixes and 7 supplementary vortex fixes were levied (Table 2-1). This was 100 more levied fixes than during 1975. Although there were 25 tropical cyclones in the Pacific area of responsibility during both 1975 and 1976, those of 1976 were generally longer lived and required 126 more warnings. This primarily accounts for the increase in levied fixes. Heavy reliance on DMSP data has continued to keep the number of aircraft levies low. For example, during 1970 470 aircraft fixes were levied for 533 warnings, whereas during 1976 only 310 fixes were levied for 635 warnings. In addition to vortex fixes 34 investigative missions were levied during 1976 compared with 21 during 1975. This increase resulted primarily from reduced timeliness, areal coverage and resolution of the DMSP satellite data. Approximately 45% of all warnings were based on aircraft fixes, 30% on satellite data, and the remaining 25% on radar, synoptic data and extrapolated positions.

Reconnaissance effectiveness is summarized in Table 2-1. The missed fix rate of 3.5% is slightly higher than the 3.2% of 1975, but remains significantly better than that from 1971 through 1974.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS	NUMBER OF FIXES	PERCENT
COMPLETED ON TIME	284	89.6
EARLY	2	.6
LATE	20	6.3
MISSED	11	3.5
TOTAL	317	100.0

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	7.6
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5

5. SATELLITE RECONNAISSANCE SUMMARY

Satellite reconnaissance of tropical cyclones is provided by the Air Force Weather Service Defense Meteorological Satellite Program (DMSP) network. This network uses data from polar orbiting DMSP spacecraft. Coverage of JTWC's area of responsibility is accomplished in the western North Pacific by direct-readout tactical sites at: Clark AB, Philippines; Kadena AB, Japan; Yokota AB, Japan; Nimitz Hill, Guam; and Hickam AFB, Hawaii. Air Force Global Weather Central (AFGWC) at Offutt AFB, Nebraska, using stored data readouts from the spacecraft, monitors the North Indian Ocean, Bay of Bengal, and Arabian Sea, in addition to backing up tactical site operations when necessary. Operational control and tasking of the DMSP network by Detachment 1, 1st Weather Wing on Guam insures that positions and intensity estimates are supplied to JTWC as tropical cyclones spawn and develop.

DMSP derived positions of tropical cyclones are categorized into six classes according to the method of gridding and type of circulation center. These classes are identified by a Position Code Number (PCN) as shown in Table 2-2. Estimates of tropical cyclone intensity are obtained using the Dvorak technique (NOAA Technical Memorandum NESS 45 and subsequent refinements).

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

CC=Circulation Center

A comparison of DMSP positions with the JTWC Best Track is shown in Table 2-3. A significant increase in satellite position error was observed in 1976. The mean deviation of 30.5 nm was an increase of 21% over the 1975 mean. This increase was attributable to the lack of Very High Resolution (VHR) visual data. Without VHR data it is frequently not possible to identify small islands and atolls necessary for precise gridding in oceanic regions. Geographic gridding was available for only 56% of this year's fixes, as opposed to 84% in 1975.

1. Yokota AB site ceased operation in December 1976. A new site at Osan AB, Korea will be providing inputs to the DMSP network in 1977.

In 1976 the number of warnings in the western North Pacific that were based on DMSP data dropped to 30%, compared with 38% in 1975 (Fig. 2-1). This decrease was due to the non-availability of sufficient and timely DMSP spacecraft. Of the warnings that were issued twice daily for the North Indian Ocean, 89% were based on satellite positions.

Use of the "dual-site" tasking concept, which requires at least two DMSP sites to make each tropical cyclone fix, resulted in 99% of the tasked fixes being accomplished.

TABLE 2-3. Mean Deviations (nm) of DMSP Derived Tropical Cyclone Positions from JTWC Best Track Positions, 1974-1976 (all sites). Number of cases shown in parentheses.

PCN	1974 (ALL SITES)	1975 (ALL SITES)	1976 (ALL SITES)
1	13.6 (224)	11.8 (214)	12.4 (131)
2	17.4 (37)	20.4 (35)	20.1 (124)
3	20.1 (422)	21.2 (271)	21.7 (161)
4	23.9 (70)	22.4 (50)	29.3 (152)
5	35.4 (342)	34.2 (323)	40.4 (247)
6	49.4 (108)	44.7 (71)	49.0 (153)
1&2	14.2 (261)	13.0 (249)	16.1 (255)
3&4	20.6 (492)	21.4 (321)	25.4 (313)
5&6	38.8 (450)	36.1 (394)	43.7 (400)
TOTAL	26.0 (1203) (35 storms)	25.2 (964) (25 storms)	30.5 (968) (26 storms)

DMSP USE RATE
(WARNINGS IN PACIFIC)

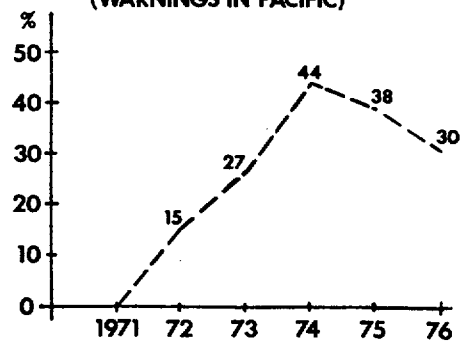


FIGURE 2-1. Percentage of western North Pacific warnings based on DMSP fixes.

6. RADAR RECONNAISSANCE SUMMARY

During the 1976 typhoon season 862 radar center fixes were received at JTWC; 859 from land stations and 3 from aircraft. A WC-130 of the 54th Weather Reconnaissance Squadron (54th WRS) fixed Typhoon Marie by radar after earlier reconnaissance had experienced severe turbulence within the eye wall. A Pan American Boeing 747 flying from Manila to Guam fixed Typhoon Louise 385 nm north of Koror at 1035Z on November 2nd. Super Typhoon Pamela was fixed 100 nm east-southeast of Truk lagoon by a Continental Air Micronesia flight enroute to Guam from Truk.

The number of radar center fixes received at JTWC during 1976 is nearly twice the 444 received during 1975. However, the 12 storms that were under radar surveillance during 1976 were less than the 14 surveyed during 1975. This paradox resulted from the fact that in 1976 tropical cyclones moved slowly through regions of dense radar coverage.

Radar reports originating from national meteorological agencies are placed into 3 categories of accuracy. These categories as defined in the WMO radar code are:

1. good [within 10 km (5.4 nm)]
2. fair [within 10-30 km (5.4-16.2 nm)]
3. poor [within 30-50 km (16.2-27.0 nm)].

Of the 707 radar report encoded in this manner, 32% were classified good, 43% fair and 25% poor. Radar reports made while storms were of typhoon intensity had 35% in the good category.

All radar reports were compared to the JTWC best track. The mean vector deviation computed for land radar was 11.6 nm. The 3 aircraft radar fixes deviated an average of 16.0 nm from the best track. During 1975 the mean deviation for land and aircraft radar center fixes were 10.1 and 16.1 nm, respectively.

Of the 862 radar center fixes received, 71% were from sites of the various national meteorological agencies, 16% were from U. S. Air Force Air Weather Service sites and 13% were received from aircraft control and warning (AC & W) sites.

Of the 12 tropical cyclones that were fixed by land radar, nine, Ruby, Therese, Wilda, Anita, Billie, Dot, Fran, Louise and Marge had tracks within range of the highly reliable and extensive network maintained by the Japan Meteorological Agency

(JMA). Five storms Ruby, Therese, Anita, Billie, and Fran were fixed simultaneously by 4 or more radar sites. Super Typhoon Fran was fixed by 10 different sites accounting for 215 fixes or 25% of the 1976 total. This represents the greatest number of fixes ever received at JTWC for a single tropical cyclone.

Geographically, sites in the Japan-Ryukyu network accounted for 83% of the 862 reports. The Philippines provided 7%, Taiwan and Hong Kong 4% each, and Guam 2%. No radar reports were received from the Indian Ocean area of responsibility.

During 1976 5% of the 689 warnings issued by JTWC were based on radar.

7. COMMUNICATIONS

JTWC receives its data and disseminates its warnings through a variety of communication systems, including AUTOVON, AUTODIN, the Naval Environmental Data Network (NEDN), and the Air Force's Automated Weather Network (AWN). Much of the basic meteorological intelligence is received via the NEDN and graphically displayed by FWC computers. More timely observations, tailored bulletins, and reports are received by JTWC on a dedicated AWN circuit directly from the AWN switch at Clark AB. AUTODIN is used for dissemination of warnings which are concurrently transmitted on the AWN.

A unique JTWC communication procedure, that between the reconnaissance aircraft and JTWC, is discussed below:

Aircraft reconnaissance data are normally received by JTWC via direct phone patch through the Andersen Aeronautical Station, which is the primary station for this purpose. Under degraded radio propagation conditions, the Clark or Yokota Aeronautical Stations can intercept and relay the data via AUTOVON and teletype to JTWC.

The preliminary eye/center data message contains sufficient information to permit JTWC to begin early preparation of individual warnings. During 1976 average communication delays for the preliminary and the complete eye/center data messages were 15 and 30 minutes, respectively. This represents a significant improvement over that of the past four years, where they had stabilized near 20 and 48 minutes, respectively. Delay times are defined as the difference between the fix time and the time of message receipt at JTWC. Table 2-4 depicts the complete eye/center data messages received more than 1 hour after fix time and after warning time.

TABLE 2-4. 1976 AIR/GROUND DELAY STATISTICS FOR AIRCRAFT RECONNAISSANCE

	1972	1973	1974	1975	1976
%Complete fix messages delayed over one hour	6	20	19	20	21
%Complete fix messages received after warning time	5.5	10.1	4.9	3.7	4.7